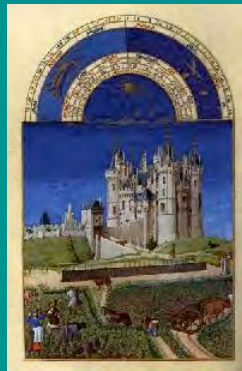


# Economic Analysis of Agricultural Sequestration Options



by

R.E. Howitt, R. Català, S. Wicks, S. DeGryze, and J. Six

# Measuring Farmer Response

- Farmers Respond to Economic incentives
- Sequestration practices will involve reduced profits from adjustments in yields and costs.
- The costs of measuring carbon directly are excessive thus farmers have to be paid by practice
- Two key questions
  - How will farmers respond to payments to adopt different practices ?
  - How will the new practices map into carbon sequestered ?

# Data Sources for Farmer Economic Response

- Primary survey of farmers
- Experimental plot yields and costs
- County Commissioner Survey data over time
- DWR county land use surveys
- Crop growth model yield changes
- Individual farmer economic response models
- Scale up individual responses to the County level

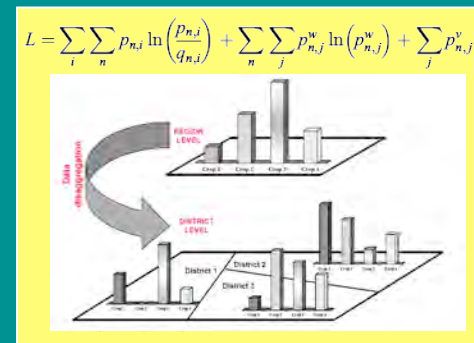
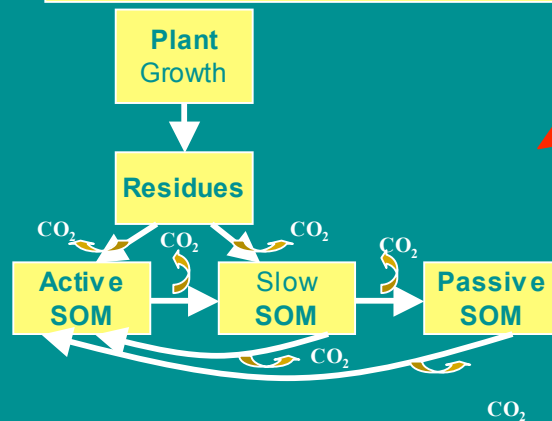
# Integrated modeling approach

Field experiments

Land use and management identification

Spatial Information

Ecosystem model

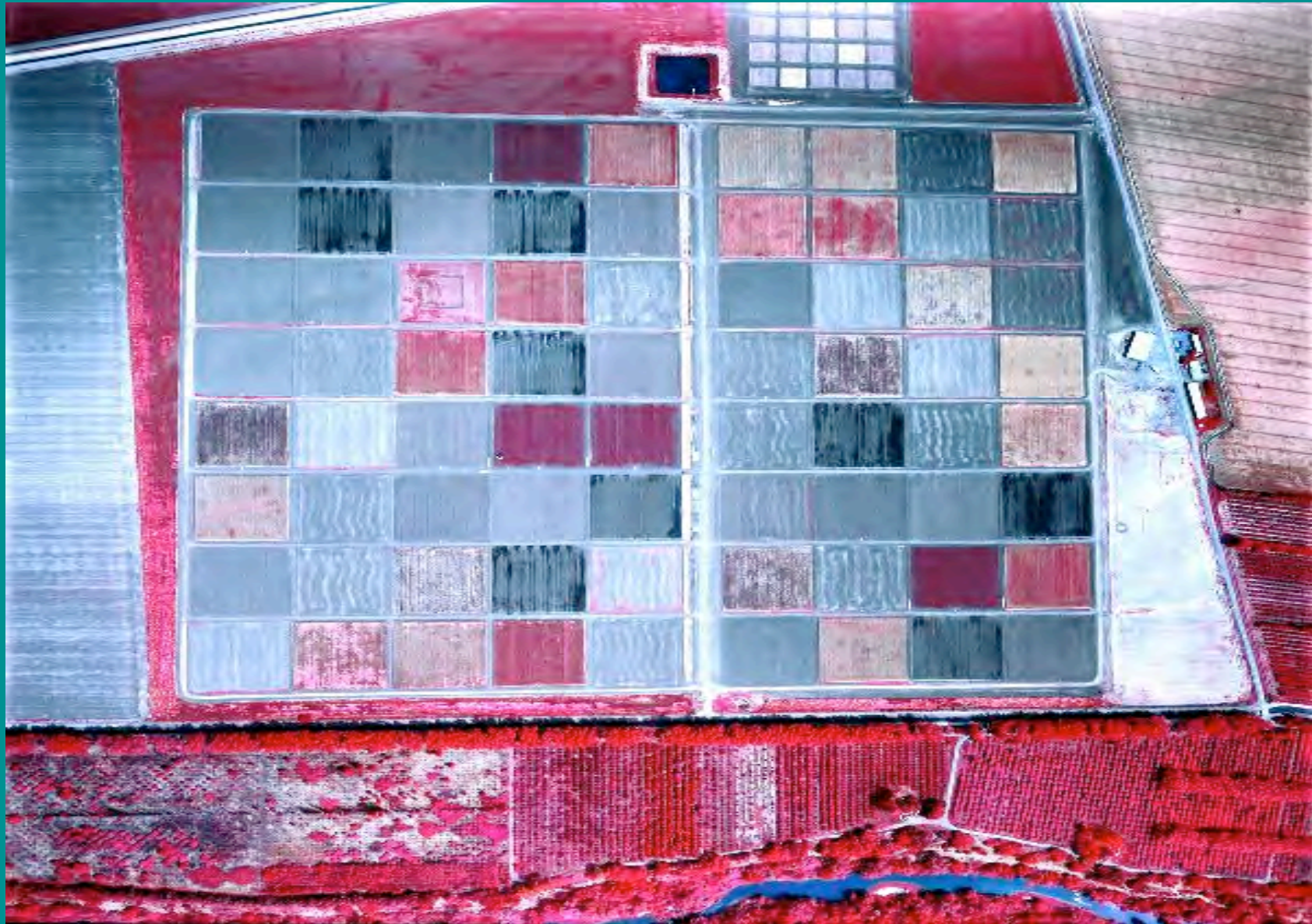


Regional

Decision support

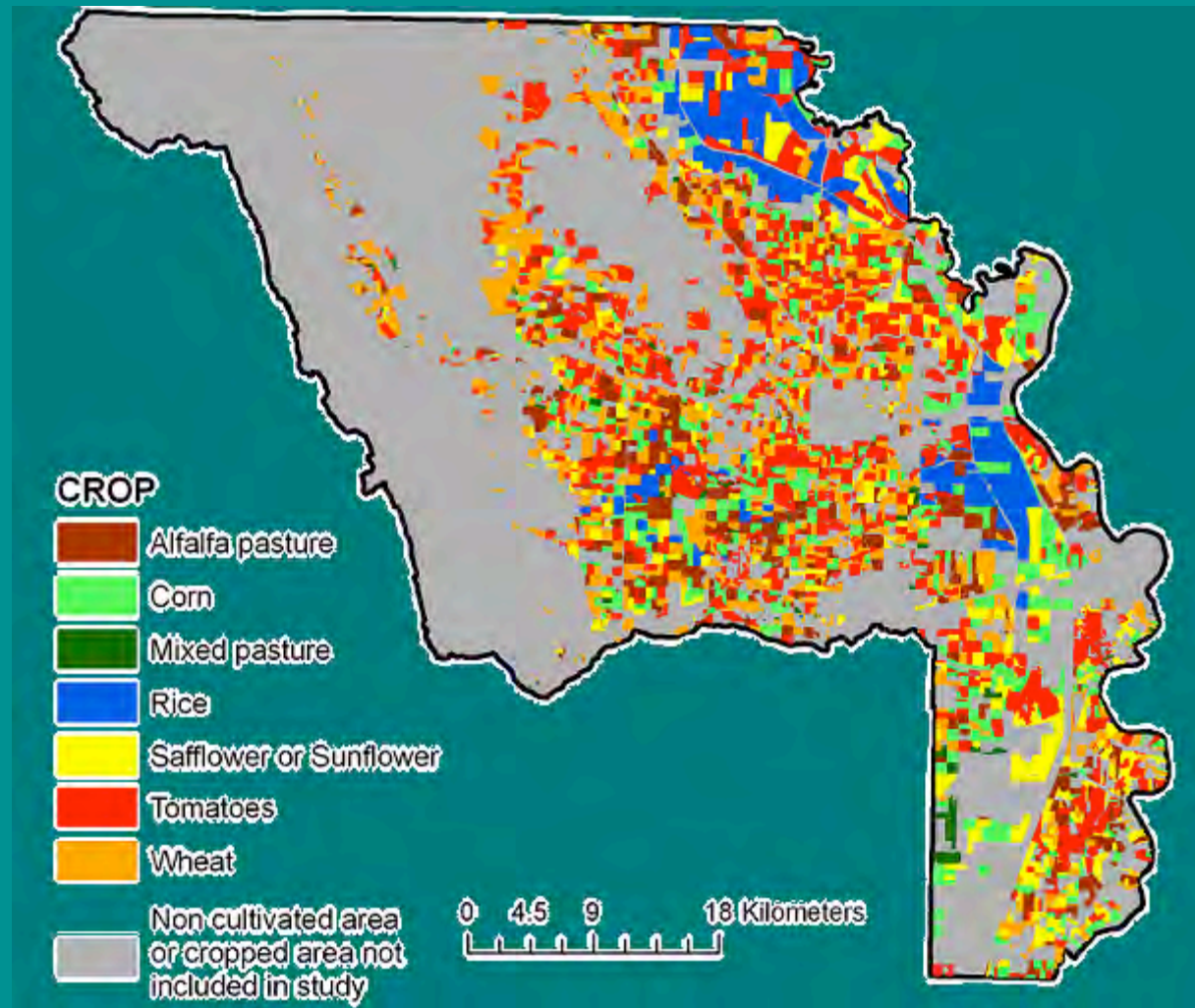
*With uncertainty estimates*

# Experimental Plot Level





# Regional Land Use- Yolo- 1997



# Farmers' choices

- **What** to grow and **How** to grow it
- Yolo Crops Surveyed:
  - **Wheat** (21.1%),
  - **Tomato** (15.6%),
  - **Corn** (12.4%),
  - **Safflower** ( 9.24%)
  - **Sunflower** ( 1.84%),
- 4 Managerial practices:
  - **Conventional** (C),
  - **Organic** (O),
  - **Conservation/Reduced Tillage** (CT)
  - **Cover Cropping** (CC)
- Potentially 24 options
  - Number of observed combinations is a lot less than 24

# Generating a Regional Carbon Sequestration Supply Response

- The regional carbon sequestration supply is the sum of the individual fields.
  - Field carbon storage depends on crop & management.
  - We have to model the farmer choices
  - Farmers differ in their soils, micro climate, water source and price expectations on crops and inputs.
- Farmers have different preferences and skills on how to manage their fields.
  - Most use Conventional methods.
  - The economic reward for switching methods to ORG, CC, or CT is currently low.
- The distribution of farmer skills and preferences can be obtained by statistical analysis



# Conservation tillage requires changes in machines and operations



# Preliminary Calculation of Mitigation Price

$$\text{Mitigation Price} = \frac{\left( \text{Net Returns}_i - \text{Net Returns}_j \right) / \text{Discount Factor}}{\text{Total Carbon Sequestration of Practice } j \text{ over } i \text{ in year } t}$$

*i = Conventional Farming*

*j = Cover Crops, Conservation Tillage, Organic.*

**Table 3: National Crop Residue Management Survey, Yolo, 1997**

	Total Planted Acres	Conservation Tillage			Conservation Tillage Total	Other Tillage Practices	
		No-Till	Ridge- Till	Mulch- Till		Reduce-Till (15-30% Residue)	Conventional- Till (0-15% Residue)
Corn (FS)	36,470	0	0	2,500	2,500	2,470	31,500
Small Grain (SpSg)	55,010	280	0	11,030	11,310	12,000	31,700
Small Grain (FISg)	69,155	1,000	0	6,155	7,155	7,500	54,500
Soybeans (FS)	0	0	0	0	0	0	0
Soybeans (DC)	0	0	0	0	0	0	0
Cotton	1,405	0	0	0	0	0	1,405
Grain Sorghum (FS)	0	0	0	0	0	0	0
Forage Crops	4,200	0	N/A	0	0	1,200	3,000
Other Crops	88,080	1,800	0	3,280	5,080	40,000	43,000
<b>TOTAL</b>	<b>257,705</b>	<b>3,080</b>	<b>0</b>	<b>22,965</b>	<b>26,045</b>	<b>63,555</b>	<b>168,105</b>
Permanent Pasture	1,300	0	N/A	0	0	0	1,300
Fallow	25,000	0	N/A	0	0	13,000	12,000
Conservation Reserve Program (CRP) Acres							
20,643							
FS-Full Season; DC-Double Cropped; SpSg-Spring Seeded Small Grain; FISg-Fall Seeded Small Grain							

Note 1: Data was collected in cooperation with USDA Natural Resources Conservation Service and Local Conservation Partnership

Note 2:

CTIC has taken all reasonable action to ensure the quality of the data, however there is no guarantee implied in the accuracy of the data at the county level.

## Expanded Crop Summary

File View Help

County California Yolo 2004

Units are Acres	Overall Acres	<u>Conservation Tillage</u> > 30% Residue			Conservation Tillage Total	<u>Other Tillage Systems</u>	
		<u>No-Till</u>	<u>Ridge-Till</u>	<u>Mulch-Till</u>		<u>15 - 30% Residue</u> (Reduced Till)	<u>0 - 15% Residue</u> (Conventional Till)
Canola	0	0	0	0	0	0	0
Forage Crops	5,100	0	n/a	0	0	1,500	3,600
Peanuts	194	0	0	0	0	194	0
Potatoes	0	0	0	0	0	0	0
Rice	32,000	0	0	0	0	10,000	22,000
Rye	0	0	0	0	0	0	0
Sunflowers	5,500	0	0	0	0	0	5,500
Sugar Beets	3,500	0	0	0	0	0	3,500
Sugarcane	0	0	0	0	0	0	0
Tobacco	0	0	0	0	0	0	0
Vegetables	100,012	2,101	0	22,411	24,512	45,000	30,500
Total Planted Acres	244,917	3,112	0	33,911	37,023	70,294	137,600
Newly Est. Perm. Pasture	1,300	0	n/a	0	0	0	1,300
Fallow	0	0	n/a	0	0	0	0
Conservation Reserve Program	16,609	n/a = not applicable			* Dry, Edible, or Snap Beans and Peas		

☒ Break out Soybeans into Full Season (FS) and Double Cropped (DC)

Note 1: Data was collected in cooperation with USDA Natural Resources Conservation Service and Local Conservation Partnership

Note 2: CTIC has taken all reasonable action to ensure quality, however there is no guarantee implied in the accuracy of the data at the county level.

View 8 Crop

View Hectares

View Percentages

Print

Help

Close

# Initial Information

- 1) SSURGO database classifies soil types within each county (geo-referenced)
- 2) We have accurate microclimate information DAYMET also geographically referenced (geo-referenced)
- 3) We have information on crop planted by farmers under conventional practices. (Pesticide Use Reports: geo-referenced)
- 4) A list of Organic farmers, and information on some CT and CC growers ( CCOF )



# The Current Farm Survey in Yolo

- To measure the distribution of farmer behavior and develop the agronomic- economic model requires field level information.
- A survey was designed to obtain information on 200 fields which were growing the 6 crops during 2005.
- Agronomic Data:
  - Planting and harvesting dates
  - Crop patterns
  - Crop and farming systems combinations
  - Cover crop combinations
- Economic Data:
  - Input costs (i.e. planting, harvesting, irrigation, inorganic fertilizers, manure, cover crops, pesticides,....)
  - Yields and total acres planted)
- The survey is currently in progress

# Modeling with the survey data

- Defining farm profits as

Price x output + Economic payment for using ORG, CC, or CT

$$\pi_i = \alpha'_i \mathbf{r}_i - \mathbf{w}'_i \mathbf{z}_i$$

Crop/manag. choice

Manag.

Skills

RevInput

prices

Inputs

Observed from survey

(unobservable)

Follows a distribution characterized by parameter  $\theta$

Econometric probabilistic choice model adjusted to the observed

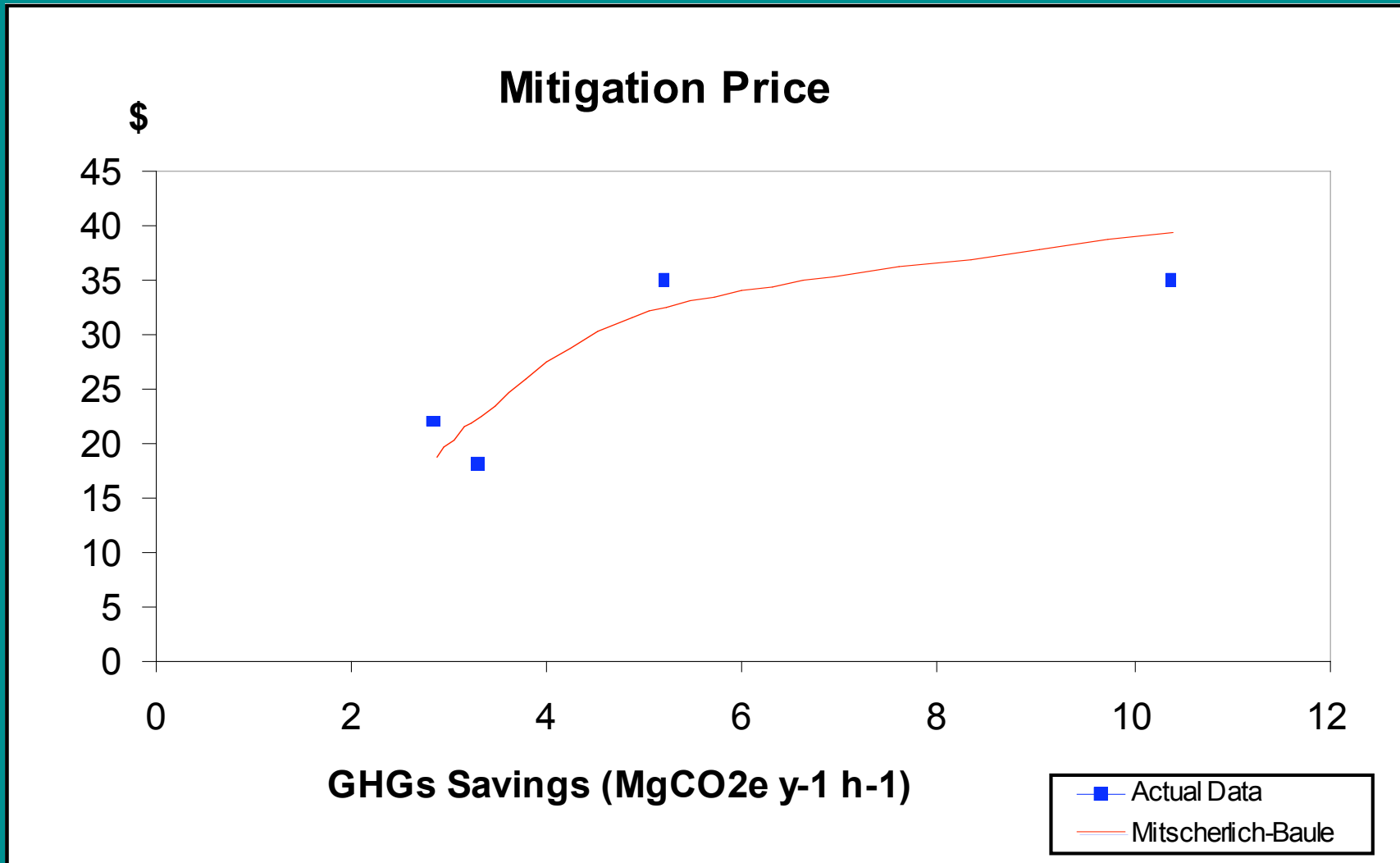
$$P(i|\mathbf{z}_B, \theta)$$

# Integrated Assessment: Economics + Agronomy

- Based on current data, the probabilistic choice model:
  - Uses both the economic and agronomic information
  - Economic behavior of farmers changes by season
  - Also depends on past crop/management and on price expectations.
- Farmers maximize profits, accounting for
  - The biophysical environment
  - Expected prices of inputs and outputs

# Aggregation to Regional Sequestration

- Using the probabilistic model and resulting sequestration payments, we simulate switching to ORG, CT, CC
- Using the agronomic model we compute the net carbon sequestration for each of those practices
- We obtain the Carbon-Sequestration supply function for the region



$$T = 40.431 \left( e^{-0.439 (\text{GHG} - 4.23)} \right)$$

$$R^2 = 0.97$$



# Conclusions

- **Use of sequestration practices show a significant technical potential for carbon sequestration**
- **We have to provide an economic incentive for farmer adoption**
- **The economic incentive cannot exceed the market price for carbon (European price \$20.85 )**
- **A regional sequestration supply function can link payments to carbon sequestration, and thus determine a cost effective payment for**